On the Shoulders of Giants? Global Science, Resource Asymmetries, and Repositioning of Research Universities in China and Russia

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Chinese and Russian universities are increasingly drawn into center-periphery repositioning, as they compete for symbolic, financial, and intellectual resources locally and globally. However, their strategies on national and institutional linkages differ with regards to the individual scientist's powers in knowledge production. As global hierarchies of knowledge productivity benchmark prestigious publications, and national industries seek access to innovative products in global research and development labs, globally connected talents become essential for elevating local research performance. This article examines the undercurrents of center-periphery repositioning in Russia and China by comparing their research and development funding and performance data, as well as contrasting their global standing with Brazil, India, South Africa, and G7 members. A method of comparative multilayered patterning of mixed data sets is used to reflect on center-periphery dilemmas facing the Chinese and Russian scientists.

Introduction

Concerns about growing inequities in higher education have been intensifying, as universities and individual academics are increasingly drawn into competition and become exposed to resource asymmetries and positions of disadvantage locally, nationally, and globally.[1] The world-class university movement was expected to rectify resource asymmetries between the privileged North and postcolonial South (Altbach 2007; Altbach and Salmi 2011). However, national recipients of privileged funding in developing countries emerged as key contributors to inequality in local resource flows (Marginson 2004). National and institutional inequities became more exposed through various ranking tables sorting intellectual and productive capacities (Cowen

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[1] Slaughter and Leslie (1997); Marginson (2004); Altbach and Balan (2007); Obamba and Mwema (2009).

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1996; Altbach 2013). For universities confronting peripherality, strategic calibration of resource providers is essential but also more difficult, as public support has become unreliable as a consequence of the changing nature, interests, and commitments of domestic protégés, sponsors, and industrial stakeholders affected by globalization.[2]

Given their potential to enhance access to larger and superior knowledge pools and to reduce costs, boundary-crossing collaborations emerged as an opportunity to level the inequities and position some universities more favorably. Nonetheless, the advantages that arise from such access are not necessarily sustainable, as collaborators confront ontological, epistemic, organizational, and cultural incompatibilities.[3] Leading contributors are more concerned about return on investment and the quality of shared outcome in competitive fields and tend to withdraw support to asymmetric collaborations earlier than in precompetitive areas of research and development (see some examples in Reich [2002] and NRC [2008]). Increasingly, partner-seekers pursue a higher status match in local and global university rankings and hence marginalize the lower strata of partakers (Marginson 2004; Slaughter and Rhoades 2004; Altbach 2013).

Equitable benefit-sharing often appears unrealizable, as collaborators are advantaged or disadvantaged by their economic, political, and sociocultural contexts (Tierney 2001; Altbach and Balan 2007; Oleksiyenko and Sá 2010). As hyperfragmented organizations facing competing multistakeholder demands (Clark 1998), research universities are often predisposed to variable growth across faculties and disciplines, receiving uneven support from industries, governments, and private sponsors (Geiger 2004; Burke 2006). Within the eclectic assortments of professional and epistemic norms and cultures that characterize boundary-crossing collaborations, there is often an imbalance in stakeholder contributions, institutional engagement, and individual commitment (Whitley 2008; Siegel 2010). In cases of success at the individual level, it can be difficult to extend the effects across the entire institution, or across the boundaries of various communities of interest (Reich 2002; Siegel 2010).

Despite the imbalances, the quest for beneficial positioning in partnerships persists, as governments expect boundary-crossing experiences to boost innovation and productivity of the national R&D systems and local economies (Wagner and Leydesdorff 2005; Royal Society 2011). At a time when anxiety about institutional status grows and the pursuit of prestige intensifies (Locke 2011), some stakeholders are also raising legitimate concerns about governance and funding of academic partnerships aimed at international problem solving in relation to global challenges (Mok 2005; Jones and Oleksiyenko 2011). Given the growing interest of higher education policy makers in pro-

[2] Clark (1998); Marginson (2004); Slaughter and Rhoades (2004); Jongbloed et al. (2008).

[3] Dill and Vught (2010); Siegel (2010); Jones and Oleksiyenko (2011); Li and Chen (2011).

moting better collaboration locally and globally, a number of studies have called for additional insights on the relational discrepancies and organizational incongruities tackled by universities across various levels of governance (Obamba and Mwembe 2009; Jones and Oleksiyenko 2011). While previous research offers ample coverage of boundary-crossing challenges at the level of institutions, the literature pays little attention to individual researchers who manage access to networks and drive advancement of institutions in national and supranational knowledge hierarchies. Yet, there are important questions about individual researchers: What types of discrepancies do they have to mitigate in these hierarchies and networks? What allows them to balance multilayered cost-benefit dependencies in disparate stakeholder communities at home and abroad? To what extent can center-periphery repositioning generate growth-share balances in collaborative science?

This article examines scientists' dependencies on stakeholder positions in driving resources toward local and global R&D networks and hierarchies. A comparative case of Chinese and Russian R&D funding and performance is used to explore these dependencies. The following section presents an analytical framework for multilayered leveraging of positioning to acquire resources in stratified science communities. The subsequent section outlines the comparative patterning of mixed data sets that reflect these dependencies. Finally, the article clarifies a number of findings and considers the implications of the growth/share dilemmas faced by the sample R&D systems, their research universities and scientists.

Disproportionate Growth and Multilayered Resource Dependencies

Robert Merton's theory of cumulative advantage/disadvantage provides an interesting departure point for a discussion of positioning challenges in science. The theory argues that hierarchies in science arise when some researchers accumulate benefits earlier and faster than their peers as a result of strategic career start-ups, mentorship, productivity, privileged networks, and prestigious institutional frameworks (Merton 1965, 1988). The proverbial "Matthew effect" often works for "high producers" who are prudently positioned for relational choices (Zuckerman 1967; Crane 1972; Slaughter and Rhoades 2004). The literature, however, also notes that "high producers" (e.g., Nobel Prize winners) tend to receive acclaim, power, and resources that far exceed what they themselves consider deserved in regards to coauthorships or other collaborative projects.

The tendency to use prestige as a proxy for excellence has a long history, an example of which Merton (1965) investigates by considering the notoriously long-standing debate on whether Newton had plagiarized key elements of his law of universal gravitation from Robert Hooke. A professor at Cambridge, Newton seemingly admitted in a private letter that he was indebted to his less famous colleague Hooke, a professor at a lesser known university in London and a correspondence coordinator and experiment curator at the Royal Society. Newton wrote to Hooke: "You have added much several ways, & especially in taking ye colours of thin plates into philosophical consideration. . . . *If I have seen further it is by standing on ye shoulders of Giants*" (Merton 1965, 31). Newton subsequently refused to give public recognition to Hooke and actually did all he could to obscure Hooke's achievements upon assuming the presidency of the Royal Society. Thus, it was never made clear on whose shoulders Newton stood. In discussing the intellectual competition-collaboration implications, Merton focused at one point on whether the italics in reprinted copies of Newton's letter, circulated among the scientific community, represented emphasis made by the author or by those scrutinizing his work and legacy. However, Merton examined the origins of the famous aphorism "standing on the shoulders of giants," often attributed to Newton; Merton tracked the aphorism back to pre-Newtonian times and rummaged through literary and historical archives to explain how the "giant-dwarf" allegory became popular in the interpretation of intellectual asymmetries long before Newton brought it back into vogue.

The study offers a reminder of the sometimes awkward and tangled web of knowledge interpretation, dissemination, borrowing, and ownership that affects collaborative science. Insofar as partnership intentions are concerned, the giant/dwarf duality appears to acquire variable meanings as the giants occasionally become dwarfs and vice versa, and scientific contributions and recognition may be filtered through asymmetries, misattributions, or misinterpretation. Also, what may be of a marginal value could become suddenly magnified or overexaggerated, while important issues are easily sidelined. Merton's work also suggests that the unfair accumulation of attributes on one or the other side of scientific relations can contribute to disproportionate growth of advantage or disadvantage in the long run.

While investigating psychosocial dynamics of productivity and collaboration in science, Merton and his colleagues (e.g., Coles and Zuckerman) gave cursory consideration to the roles of national contexts and institutional climates in achieving individual success. The institutional perspective of cumulative advantage acquired weight with Philip Altbach's framing of a world-class university and its role in the reinforcement of center-periphery divides in higher education. Altbach and his colleagues (see, e.g., Altbach and Balan 2007, Altbach and Salmi 2011) outlined strategies promoted by a select number of nation-states to support their leading institutions in the acquisition and concentration of intellectual and material resources. The simultaneous impact of global, national, regional, and local pressures on human and institutional agencies of higher education (Marginson and Rhoades 2002) has further moved the discussion in favor of multilayered analysis of institutional strategies in globalizing environments (Jones and Oleksiyenko 2011). In the multilayered center-periphery constructs, it is not only developing countries and their institutions, but also some faculties and disciplines in well-off R&D systems that can appear on the outskirts of the "empires of knowledge" (Altbach 2007). Nations, institutions, faculties, research centers and individuals are destined to be marginalized if they do not create the necessary plug-ins for connecting with and utilizing the intellectual and/or financial flows that intermittently emerge at the lower or upper levels of the multilayered governance matrices (Jones and Oleksiyenko 2011).

The institutional cases collected by Altbach and Salmi (2011) provide ample evidence about how universities gain or lose opportunities to determine their global standing. To break the cycles of disadvantage, universities tend to espouse strategies to reorganize governance, attract and retain talents, increase productivity, and promote themselves in the global knowledge networks (Altbach and Salmi 2011). However, what is often missed is that "catching up" in the global race requires sustainable commitments not only from governments, industrial sponsors, or university leaders but also from individual scientists. In the current hierarchy of higher education, the individual's assortment of strategic stakeholders and sustainable productivity at the world-class level either enhances or reduces the asymmetric positions of their institutions and nations (Oleksiyenko and Sá 2010). As higher education systems and their universities compete for resources in expectation of strengthening their global positions or moving out of the periphery to the center of global knowledge production, dependencies of the scientists' research strategies on systemic and institutional support deserve greater attention.

A Comparative Study of China and Russia

To explore these dependencies, this article conducted a comparative study of the rapidly transforming research systems of China and Russia. The study examined research performance and funding data included in the statistical reports of international agencies (e.g., UNESCO, OECD [Organization for Economic Cooperation and Development], Thomson Reuters), previous studies on Chinese and Russian research universities, and consultations with higher education experts in the two countries. The quantitative data were analyzed in comparison with equivalent data sets from major global alliance members, the BRICS (Brazil, Russia, India, China, and South Africa), and G7 members (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States). Juxtaposing the data sets made it possible to see the Russian and Chinese positions within a larger context of international R&D relations.

The repositioning-related challenges were tracked at three levels: superstructure, structure, and understructure. At the superstructure level, a multicountry comparison of general expenditures on R&D (GERD) and fluctuations in major components, such as higher education R&D (HERD), business R&D (BRD), government R&D (GRD), and foreign R&D (FRD), were analyzed to illustrate the growth or reduction of asymmetries in the national redistributive mechanisms. Comparative data were primarily drawn from international data sets provided by UNESCO and OECD. At the structure level, this study examined performance criteria in national higher education system rankings (e.g., Universitas 21-U21) and university rankings (e.g., Shanghai Jiao Tong University Academic Ranking of World Universities [ARWU] and Times Higher Education [THE]). The institutional level in each country was represented by the two top research performers in ARWU and/or THE. Correlations between funding at the superstructure level and performance at the structure level were scrutinized. Finally, at the understructure level, the paper correlated the preceding interdependencies with researchers' total production and international coauthorship in SCI (Science Citation Index) and SSCI (Social Science Citation Index) publications.

At each level, the growth trajectories were compared with the help of time series analysis of R&D funding and performance in China and Russia, in juxtaposition with similar data from low- to middle-income countries (as represented by BRICS) and high-income countries (as represented by several G7 members). Given the consistency of criteria and data collection approaches in the above-mentioned international databases and ranking systems, longitudinal trends and challenges were tracked. Comparative multiscalar analysis allowed for correlating a range of variables reflecting the often-ambiguous layers of contextual and organizational changes taking place simultaneously across the local, national, and global domains (Marginson and Rhoades 2002). Cross-layer cascade effects were compared across the sampled R&D systems in BRICS and G7 countries.

To mitigate the analytical generalization limits imposed by the sample and the focus on research performance and funding within several countries, the study conducted data triangulation to enhance construct validity. The additional data sources included policy statements by ministries of education, science, and technology, and national academies of sciences; university strategic plans and annual reports; and online narratives and scholarly publications in English, Chinese, and Russian. In addition, 10 university experts ($N = 5$ in Russia, and $N = 5$ in China) provided insights into the interpretation of some data and identified gaps in the evolving analytical construct.

The analytical narrative applies the "giant-dwarf" aphorism to controversial interpretations in science, which are affected by asymmetries and cumulative (dis)advantages in collaborative relations. Both universities and scientists in China and Russia lived through giant-dwarf transformations at various times. Having followed the Soviet model of higher education since the 1950s, China abandoned it to compete with the new global giants—the United States and Japan—half a century later. As a world mega-economy on the rise, China began to transform its academic R&D from dwarf to giant in the global research university rankings. Dwarfed by the collapse of the Soviet Union, Russia has also been making efforts to regain its once-robust powers in global science. Russian policy makers recently tried to emulate China's strategy of lifting national research universities in the global hierarchies of knowledge through selective funding programs. While both countries aspire to reposition their sciences, their strategies in handling global asymmetries have acquired contrasting approaches to stakeholder configurations and outreach to global science. The discussion below focuses on differences, inconsistencies, and gaps in the configurations of emerging global "scientometrics" that are sometimes politicized in the context of emerging tensions between the global scientific North and South, as the center-periphery repositioning intensifies.

Findings: Producers and Produced

The global competitiveness of universities depends on resource distribution controlled by local stakeholders, including governments, industries, and universities. Academics emerge as critical producers in moving national and institutional positions in global hierarchies. However, those efforts can be either energized or dampened by stakeholders who have complementary or competing interests and commitments. To some extent, the lingering Soviet tradition of "academic commitment to industrial interests" placed Chinese and Russian academics in an advantageous position to draw on cross-sectoral R&D funds, whereas academics in other countries (e.g., Canada and the United Kingdom) have struggled in that respect (Slaughter and Leslie 1997; Froumin and Salmi 2007; Mok 2008). Moreover, the growing influence of the global economy on the Chinese national R&D portfolio and the tightening grip of authoritarian state control in Russia have yielded different outcomes: on the one hand, internationalizing Chinese businesses have accelerated academic internationalization, and vice versa, facilitating a more immediate plug-in to global norms of production, productivity, and competitiveness; on the other hand, Russian protectionism has pushed industrial and academic R&D to the bottom of the global performance pyramids. These outcomes demonstrate how academic "producers" (Crane 1972) are affected by the broader economic system in which they work.

Given their common desire to elevate their positions in the global hierarchies of science, Chinese and Russian academics are seeking greater autonomy to compete for prestigious grants, awards, and influence in world-leading journals. Over the last decade, Chinese universities have been restructuring academic governance to improve their productivity in SCI publications (Hayhoe et al. 2010). In contrast, most Russian universities have continued to rely on European-style bureaucratic steering embedded in heavily regulated teaching (Hayhoe 1989), and only some encouraged their scientists to give more attention to globally connected curiosity-driven research (Froumin and Salmi 2007). Senior scientists who are cross-affiliated with the Russian Academy of Sciences are the exception when it comes to publishing, but many of them tend to attribute their production to the science academy rather than to their home university. While Russian university administrators may be reluctant to go along with the challenge of productivity benchmarking in global hierarchies, the revival of patriotic and nationalist sentiment in Russia has resulted in a loss of traction with Europe that itself is in "catch-up" mode (Guriev 2009; Kortunov 2009, Horta 2010). The local-global tug-of-war becomes more intense as post-Soviet Russia and China watch and nudge each other toward greater competition and fuel ambitions for center-periphery repositioning between the scientific North and South. The changing stakeholder power configurations at the superstructure, structure, and understructure levels demonstrate the shift of paradigms in global competition and collaboration.

Superstructure

In 2012, Universitas 21 consolidated over 20 indicators to compare the performance of 48 leading national higher education systems, identified by the American National Science Foundation as the top 2006–7 research performers. China and Russia scored relatively low on this evaluative scheme due to more limited resources (measured by government expenditures, total expenditures, and R&D expenditures on tertiary institutions) and poor connectivity (represented by numbers of inbound international students and journal publications coauthored with international collaborators). While Russia was slightly ahead of China (see table A1; tables A1–A8 available online), China outperformed Russia in the categories of environment (e.g., data quality, gender balances, regulatory climate) and output (e.g., scientific publications, world-class universities).

Further evidence of improvement in China's environment and outputs is found in the ARWU's top 500–ranked universities list; the number of Chinese world-class universities grew from 8 to 34 between 2005 and 2010 (see table A7). This rise is particularly impressive when compared to Russia's lack of progress over the same period. With a large higher education system (1,129 universities) and limited resources, China achieved results through preferential funding of top performers, which spearheaded institutional differentiation, stimulated domestic competition, and led to the adoption of global isomorphism (Cai 2010). For example, the Chinese government's 1990s policy favored a small group of contenders among China's 1,129 universities: its 211 Program selected and provided preferential funding to the top 112 universities, and subsequently, the 985 Program filtered the recipients down to 39. The Chinese government dramatically increased GERD in total, as well as per researcher, over the last decade (seven times and almost three times, respectively; see table A2). China appeared to be working harder than its BRICS counterparts and outperformed the G7's Canada and Germany, outpacing every other country among the BRICS and G7 members (except the United States) in total expenditures by 2010. Meanwhile, Russian academics were chiefly concerned with ensuring a "fair and equal system." As one study participant put it, there was a concern that "[Russia's] vast territory, including immense permafrost Siberia, also needed universities and research" (also see Markusova et al. 2004). According to Gokhberg and Kuznetsova (2010), 78 percent of Russia's 1,134 universities performed some level of R&D.

Given the contrasting approaches, the cross-stakeholder distribution of R&D resources in China and Russia and the low performance and funding indicators in the university sectors of the two countries (around 8 percent of the national R&D budget in 2010; see table A3) had different implications. China concentrated resources in the designated "Ivy League" universities, while Russia was spreading the budget as wide as possible until recently.

Funding of public versus private stakeholders presents another contrast. Between 2000 and 2010, China shifted research resources to industry, while Russia favored governmental laboratories controlled by the National Academy of Sciences. Chinese industry increased its share of the total R&D funding from 58 percent to 72 percent, while the share for government institutions decreased from 33 percent to 23 percent. Given these numbers alone, Chinese and Russian universities with 8 percent performance in the GERD may appear as losers in the global R&D layouts (especially as compared with other global players, such as universities in Canada and Brazil with 38 percent, and South Africa and the United Kingdom with over 20 percent).

However, indicators of university-industry linkages, as revealed in the 2010 THE rankings, show that China outperforms leading American universities (table A4). Indeed, China surpassed all BRICS and G7 countries in terms of the higher education R&D share funded by industry. This flow of funds increased from 32.3 percent to 33.2 percent between 2000 and 2010 and achieved a higher volume of HERD (in purchasing power parity [PPP$]) than in Canada and Germany (table A5). Furthermore, China's National Hi-Tech 863 program was reported to have 57.9 percent of its 1,220 projects in biotech, material sciences, and agriculture implemented by universities. The proportion of academic engagement is most likely to be even higher given that the 863 projects implemented by industry and state-owned research enterprises engaged university researchers (Mu 2010, 387).

At the same time, the percentage of funds for basic research in China declined from 5.2 to 4.6 percent. In comparison, this proportion has grown in Russia from 13.4 to 19.6 percent and in the United States from 15.9 to 18.9 percent between 2000 and 2010 (table A6). China has also empowered its industries to "borrow" ideas globally. For example, Huawei Technologies set up five research institutes in Silicon Valley and Dallas (Unites States), Bangalore (India), Sweden, and Russia to access world knowledge (OECD 2008). Other enterprises, like Lenovo and GEELY, were "accessing foreign R&D resources by means of transnational acquisitions" (Mu 2010, 389–90). Back home, Chinese authorities admitted to their country's increasing dependence on foreign direct investments, which also implied a growing demand among globalizing enterprises for Chinese graduates with multinational competencies (Weifang 2012). This required Chinese authorities to shift their rhetoric from benchmarking "the old-days national culture and pride in sciences" to "winning the modern global game, which can later boost the pride."

In Russia, the proportion of industrial money in the GERD declined from 33 to 25 percent, while governmental expenditures increased from 55 to 70 percent, primarily for fundamental and applied research performance in governmental and university labs (see tables A3 and A6). In a reversal of the post-Soviet democratization and decentralization of the 1990s, Russian policies of the 2000s have aimed at tightening bureaucratic control in accordance with Soviet templates, sometimes for the sake of improving Russia's national science and technology standing in increasing global competition. For example, a radical reform of the 289-year-old Russian Academy of Sciences, an archaic institution with a historical legacy of anti-Western sentiments (although still a top Russian performer, according to SCOPUS results in table 5), was viewed by some scientists as an attempt of the Russian government to enhance the country's global standing by rearranging power relations among research institutions and universities at home.

Structure

Russia's reforms aimed at catching up with China have been slow. Only two Russian universities—Moscow State University and St. Petersburg State University—appeared in the ARWU 2003 top 500 league, in the 102–51 and 401–50 spots, respectively. In defiance, the Russian rankers developed their own world university ranking system in which Moscow State University occupied the top position. However, as global recognition of ARWU expanded, while the Russian ranking system failed to receive acclaim and a growing number of global university leagues disdained Russian institutional performance, the Russian government switched course in 2008, deciding to launch radical reform of its higher education system.

This 2008 reform involved a preferential funding model, creating competitive research foundations, sending scholars abroad, and seeking out international collaborative enterprises with top universities. Russia designated 29 "national research universities" and nine federal universities to lead the R&D agenda nationally. In 2013, Russia pursued the so-called 5/100 scheme, aiming to have five national universities join the top 100 world-class universities by 2020. Meanwhile, China saw the emergence of C9 (i.e., "Chinese Ivy

League"), comprising nine leading universities from among the former 211 and 985 Program funding recipients.

Russia's 5-100-2020 ambition was a big stretch in the absence of a clear understanding of the Chinese implementation steps. Chinese universities were able to rise higher and faster in rating systems like the ARWU, which emphasize verifiable numbers (e.g., number of prizes, citations) rather than expert opinions on which the THE international rankers rely (table A7). As one of the Chinese observers noted, "the Chinese scholars would not be able to do well in the systems where Western buddies praise Western buddies." Indeed, what the ARWU-THE juxtaposition shows is that all the BRICS members do better in the numbers-driven, rather than opinion-influenced, race.

Moreover, success was not merely dependent on resource concentration and access to privileged money. Chinese universities invested in increasing cross-border mobility, global networking, and SCI publication incentives, as well as in recruiting and reintegrating Chinese scholars who were enjoying successful careers at the top 500 ARWU American and Canadian universities. Alas, the reintegration resulted in major strains in relations between locals and returnees (Yang 2009; *Economist* 2013). It was the painful restructuring and discriminative compensation and tenure schemes that allowed the 211 and 985 investments of the 1990s to provide good returns a decade later.

A close-up of a sample of SJTU-ranked research universities shows that China's top research performers (Peking University and Tsinghua University) have been placing significant emphasis on advancing their positions in the production of SCI-indexed papers, including in the two highest impact-factor journals, *Nature* and *Science* (table A7). While they still struggled to keep up per-capita academic performance, Peking University and Tsinghua University showed consistently higher results across the production of indexed papers than Russia's Moscow State University and St. Petersburg University in the Shanghai ranking league. In general, cross-country and cross-institutional analyses of publication and citation ratios suggest that universities at the summit of the ranking pyramid tend to experience fluctuations in their performance too, and hence their positions of power are vulnerable, especially in the absence of consistent performance of individual researchers. Note, for example, the overall decline in the "per capita academic performance" in sampled universities, except for Berkeley, in table A8.

Understructure

Real change in global repositioning primarily depends on "high producers" (Crane 1972) who increasingly play decisive roles in global science networks and participate in international symposia, peer-reviewed publications, academic mobility, and Internet-based exchanges. As table 1 demonstrates, the annual world output of SCI/SSCI publications grew from year to year over the last decade (from 768,173 in 2000 to 1,152,090 in 2010).

TABLE 1

Selected Countries' SCI and SSCI Publications Output (2000–2010)

	National Number of Papers						World Total (%)				National Number of Papers, Social Sciences						% of Social Science Articles in the Total No. of Articles			
	2000			2010			2000		2010		2000			2010			2000		2010	
Country	NT	Uni.	Uni./NT (%)	NT	Uni.	Uni./NT (%)	NT	Uni.	NT	Uni.	NT	Uni.	Uni./NT (%)	NT	Uni.	Uni./NT (%)	NT	Uni.	NT	Uni.
Brazil	10,773	8,781	81.5	31,591	28,487	90.2	1.4	1.6	2.7	3.0	441	384	87.1	3021	2713	89.8	4.1	4.4	9.6	9.5
Russia	26,857	13,445	50.1	26,538	14,638	55.2	3.5	2.4	2.3	1.6	577	262	45.4	611	336	55.0	2.1	1.9	2.3	2.3
India	16,780	7,492	44.6	41,304	20,613	49.9	2.2	1.4	3.6	2.2	387	151	39.0	1,227	684	55.7	2.3	2.0	3.0	3.3
China	29,905	23,781	79.5	137,320	122,225	89.0	3.9	4.3	11.9	13.0	864	807	93.4	4,906	4,606	93.9	2.9	3.4	3.6	3.8
South Africa	3,498	3,069	87.7	7,430	7,060	95.0	.5	.6	.6	.7	387	350	90.4	1,693	1,631	96.3	11.06	11.4	22.8	23.1
Canada	32,572	28,645	87.9	52,431	48,903	93.3	4.2	5.2	4.5	5.2	4,431	4,148	93.6	9,963	9,576	96.1	13.6	14.5	19.0	19.6
Germany	65,216	51,140	78.4	84,654	70,901	83.7	8.5	9.3	7.3	7.5	3,369	2,591	76.9	8,133	6,907	84.9	5.2	5.1	9.6	9.7
Japan	72,503	57,282	79.0	72,694	62,264	85.6	9.4	10.4	6.3	6.6	1,208	1,047	86.7	2,466	2,298	93.2	1.7	1.8	3.4	3.7
France	47,393	27,158	57.3	60,742	47,643	78.4	6.2	4.9	5.3	5.1	1,916	1,155	60.3	4,327	3,418	79.0	4.0	4.2	7.1	7.2
USA	247,667	193,912	78.3	319,921	270,424	84.5	32.2	35.2	27.8	28.8	39,067	32,151	82.3	62,824	54,961	87.5	15.8	16.6	19.6	20.3
World	768,173	551,019	71.7	1152,090	939,076	81.5	72.0	75.3	72.4	73.8	79,202	58,721	74.1	153,609	130,451	84.9	10.3	10.7	13.3	13.9

Source.—Compiled from Thomson Reuters, "Web of Science: Core Collection," accessed via http://apps.webofknowledge.com.
Note.—NT = national total; Uni. = university-based; SCI = Science Citation Index; SSCI = Social Sciences Citation Index.

Universities played a greater role by increasing their contribution to this volume from 70 to 81.4 percent. China's overall output in the world production increased almost fourfold (from 29,905 to 137,320), while the universities' stake in the national SCI/SSCI output grew from 79.5 to 89 percent. China's proportion of world output increased from 3.9 to 11.9 percent between 2000 and 2010. This increase took place primarily in science and technology domains (96.38 percent of the total), while social sciences and humanities continued to lag behind, even after some increase (from 2.3 to 3.0 percent, compared with the world's average of 10.3 to 13.3 percent) during this period. Although it started out on equal footing with Russia in 2000, China outperformed Russia sevenfold in SCI output and ninefold in SSCI output a decade later. Meanwhile, Russian performance in this category stayed relatively stagnant (26,857 in 2000 to 26,358 in 2010). Russian SCI/SSCI production remained almost equally split between the National Academy of Sciences and universities. The latter's output increased over the last decade, but insignificantly. In 2010, China claimed the best performance in the SCI/SSCI category among the BRICS and G7 countries. This result was in sync with the rise of Chinese universities in the ARWU university rankings.

While the overall publication record looks interesting, the picture changes somewhat when the focus shifts to the publication volume per R&D personnel. An analysis of the R&D personnel capacities in the Chinese and Russian systems sheds light on the earlier mentioned discrepancies. Russia's R&D personnel head count (HC) and full-time employment (FTE) numbers indicate that academic researchers have been overemployed, simultaneously holding several full-time positions (53,290 HC per 113,353 FTE positions), while in China almost 50 percent of the university-based R&D personnel were underemployed (593,569 HC per 289,670 FTE; table 2). Besides, China's academic R&D workforce was 10 times larger than Russia's in 2010, while Russia saw declining HC and FTE numbers over the last decade. Provided that China could employ its R&D personnel fully and increase the productivity of its research staff in terms of SCI/SSCI publications, it would most likely become a global leader in both world output and world-class university performance.

China's position, however, depends on the performance of other R&D systems. Japan's recent slip from the second position in global output is partly due to a 40,000 FTE decline in the Japanese academic R&D personnel and a doubling of part-time positions (e.g., 375,160 HC per 188,324 FTE in 2010; see table 3). China's ability to overtake Japan can also be explained by a nearly double increase of FTE R&D positions across all of its sectors: industry, government, and academic (from 922,131 in 2000 to 2,553,828 in 2010, including from 159,246 to 289,670 in Chinese universities, as compared with a decline from 227,882 to 188,324 in Japan). It is not clear what path China would take in the future when other systems (e.g., Brazil, Germany) increase

TABLE 2
Head Count (HC) and Full-Time Equivalent (FTE) Personnel in the National R&D Systems

	Total R&D Personnel (HC)				Total R&D Personnel (FTE)			
	Number		%		Number		%	
	2000	2010	2000	2010	2000	2010	2000	2010
Brazil:								
Industry	86,183	66,212	37.2	14.1	55,436	55,436	41.7	20.8
Government	8,691	14,187	3.7	3.0	8,691	14,187	6.5	5.3
Universities	136,658	391,222	59.1	83.4	68,331	195,614	51.4	73.3
Private nonprofit	544	1,472	.2	.3	544	1,472	.4	.5
Russia:								
Industry	590,646	423,112	66.5	57.4	628,858	444,111	62.4	52.8
Government	255,850	259,007	28.8	35.1	276,373	280,506	27.4	33.4
Universities	40,787	53,290	4.6	7.2	99,552	113,353	9.9	13.5
Private nonprofit	446	1131	.05	.15	2,474	2,022	.2	.24
China:								
Industry	NA	2,432,903	NA	68.6	532,114	1,873,913	52.1	73.4
Government	NA	515,772	NA	14.6	282,094	390,245	30.6	15.3
Universities	NA	593,569	NA	16.7	159,246	289,670	17.3	11.3
Private nonprofit	NA	NA	NA	NA	NA	NA	NA	NA
German:								
Industry	(342,978)	(383,559)	(50.1)	(49.5)	312,490	337,211	64.4	61.4
Government	(84,695)	107,997	(12.7)	(13.3)	71,454	90,531	14.7	16.5
Universities	(246,751)	301,633	(37.1)	(37.1)	100,790	120,784	20.8	22
Private nonprofit	NA	NA	NA	NA	NA	NA	NA	NA
Japan:								
Industry	(629,487)	696,973	(59.9)	60.1	581,721	614,772	64.9	70
Government	68,887	70,941	6.6	6.1	59,254	61,830	7.2	7.0
Universities	308,525	375,160	(31.5)	32.4	227,882	188,324	25.4	21.5
Private nonprofit	21,386	(16,472)		1.4	27,990	13,002	3.1	1.5

Source.—Compiled from UNESCO (2013).
Note.—NA = data not available.

TABLE 3
SCI/SCCI PRODUCTIVITY PER R&D HEAD COUNT (HC) AND FULL-TIME EQUIVALENT (FTE)

	R&D HC in Universities		R&D FTE in Universities		SCI/SCCI Papers Produced in Universities		Productivity per HC		Productivity per FTE	
	2000	2010	2000	2010	2000	2010	2000	2010	2000	2010
Brazil	136,658	391,222	68,331	195,614	8,781	24,487	.06	.06	.128	.125
Russia	40,767	53,290	99,552	113,353	13,445	14,638	.33	.27	.135	.129
China	NA	593,569	159,246	289,670	23,781	122,225	NA	.2	.15	.42
Germany	246,751	301,633	100,790	120,784	51,140	70,901	.21	.23	.51	.59
Japan	368,525	375,160	227,882	188,324	57,282	62,264	.15	.16	.25	.33

SOURCE.—Compiled from UNESCO (2013); Thomson Reuters, "Web of Science: Core Collection," accessed via http://apps.webofknowledge.com.
NOTE.—NA = data not available.

TABLE 4

2000–2010 International Coauthorship of SCI-SSCI Papers between BRICS and G7

	World	Brazil	Russia	India	China	South Africa	Canada	France	Germany	Italy	Japan	UK	US
World	Σ10,178,561 1,152,124 768,170												
Brazil		Σ213,340 31,591 10,773	Σ1,951 255 166	Σ1,363 255 54	Σ1,509 99 71	Σ516 105 14	Σ4,098 593 216	Σ7,870 1,107 501	Σ6,630 934 408	Σ4,093 606 228	Σ2,062 260 110	Σ7,385 1,004 474	Σ22,938 3,067 1,429
Russia			Σ280,403 26,538 26,857	Σ1,806 306 80	Σ3,650 528 179	Σ434 82 31	Σ4,339 415 316	Σ13,438 1,368 1,098	Σ25,966 2,284 2,138	Σ8,476 818 674	Σ7,622 619 639	Σ10,449 1,048 884	Σ24,501 2,186 2,062
India				Σ295,831 41,305 16,780	Σ2,940 489 118	Σ682 150 28	Σ3,067 532 154	Σ4,673 756 225	Σ8,212 1,156 437	Σ2,686 497 138	Σ5,707 698 296	Σ6,628 1,005 369	Σ19,702 2,844 1,126
China					Σ831,517 137,329 29,905	Σ758 167 29	Σ14,187 2,541 451	Σ9,439 1,692 332	Σ15,982 2,546 713	Σ4,104 741 227	Σ25,728 3,504 1,142	Σ18,760 3,213 745	Σ75,959 14,685 2,561
South Africa						Σ54,523 7,430 3,498	Σ1,603 271 88	Σ2,145 373 99	Σ3,064 449 167	Σ993 202 44	Σ763 142 41	Σ5,895 919 327	Σ8,055 1,233 435
Canada							Σ452,082 52,431 32,572	Σ18,187 2,524 1,089	Σ17,607 2,537 952	Σ9,077 1,417 472	Σ9,735 1,075 743	Σ25,406 3,464 1,460	Σ98,776 12,121 6,397
France								Σ576,446 60,742 47,393	Σ42,700 5,523 2,811	Σ31,419 4,163 1,934	Σ12,277 1,552 846	Σ41,361 5,479 2,679	Σ67,220 8,311 4,822
Germany									Σ797,490 84,654 65,216	Σ30,852 4,215 1,908	Σ18,066 2,078 1,360	Σ53,594 7,321 3,240	Σ105,322 12,655 7,334
Italy										Σ433,168 48,314 31,011	Σ7,215 930 479	Σ32,166 4,403 2,002	Σ55,002 6,958 3,524
Japan											Σ815,511 72,694 72,503	Σ16,734 1,953 1,227	Σ70,606 6,884 5,680
UK												Σ824,179 87,302 69,526	Σ118,154 14,362 8,142
US													Σ3,050,652 319,926 247,667

Source.—Compiled from Thomson Reuters, “Web of Science: Core Collection,” accessed via http://apps.webofknowledge.com.

Notes.—Numbers at the bottom refer to output in 2000; center = 2010; top = total, 2000–2010.

TABLE 5
SCIMago Ranking of Research Institutions by SCOPUS, 2006–10

WR	RR	CR	Organization	Sector	Country	Region	O	%IC	NI	%Q1	Spec.	%Exc	%Lead	%EwL
1 →	1 →	1 →	Centre National de Ia Recherche Scientifique	GO	FRA	WE	204,784 ↑	50.55 ↑	1.32 ↑	58.37 ↓	.54 →	15.81 ↓	59.52 ↓	8.41 ↓
2 →	1 →	1 →	Chinese Academy of Sciences	GO	CHN	AS	146,249 ↑	22.15 ↑	.98 ↑	40.54 ↑	.64 ↓	11.69 ↑	67.2 ↓	7.51 ↑
3 →	1 →	1 →	Russian Academy of Sciences	GO	RUS	EE	92,894 ↑	33.81 ↓	.53 →	23.35 ↓	.73 →	4.42 ↓	70.78 ↑	1.37 ↓
4 →	1 →	1 →	Harvard Univ.	HE	USA	NA	75,146 ↑	35.92 ↑	2.39 ↑	78.31 ↑	.54 ↑	29.2 ↓	45.22 ↑	12.04 ↑
5 →	2 →	1 →	Helmholtz Gemeinschaft	GO	DEU	WE	56,128 ↑	55.11 ↑	1.54 ↑	59.49 ↑	.64 →	18.68 ↑	50.26 ↓	7.92 ↓
6 →	3 →	2 →	Max Plarick Gesellschaft	GO	DEU	WE	51,893 ↑	65.3 ↑	1.83 ↑	72.31 ↑	.67 →	24.29 ↑	47.89 ↓	11.44 ↓
7 →	2 →	1 →	Univ. of Tokyo	HE	JPN	AS	50,742 ↑	26.96 ↑	1.25 ↑	54.54 ↓	.51 →	14.02 ↓	55.68 ↓	6.71 ↓
8 →	2 →	2 →	National Institutes of Health United States	HE	USA	NA	47,691 ↑	36.05 ↑	2.26 ↑	81.86 ↓	.73 ↑	27.91 ↑	52.06 ↓	13.59 ↓
9 →	3 →	1 →	Univ. of Tokyo	HE	CAN	NA	46,756 ↑	41.9 ↑	1.79 ↑	66.54 ↓	.4 →	20.82 ↓	51.39 ↑	9.05 ↓
10 ↑	4 →	1 →	Con sejo Superior de Investiga-ciones Cientificas	GO	ESP	WE	46,177 ↑	50.56 ↑	1.44 ↑	69.96 ↓	.61 ↓	17.31 ↑	55.05 ↓	8.9 ↓
11 ↓	3 →	2 →	Tsinghua Univ.	HE	CHN	AS	45,312 ↑	18.24 ↑	.91 ↑	29.4 ↑	.67 ↓	11.06 ↑	75.31 ↓	7.66 ↑
12 ↑	1 →	1 →	Universidadede Saa Paula	HE	BRA	LA	44,945 ↑	24.81 ↑	.83 ↓	38.26 ↓	.51 →	7.93 ↓	61.71 ↓	3.84 ↓
13 ↓	4 →	3 →	Univ. of Michigan, Ann Arbor	HE	USA	NA	44,442 ↑	26.11 ↑	1.99 ↓	70.76 ↓	.38 ↑	24.03 ↓	59.8 ↓	12.64 ↓
14 ↑	4 ↑	3 ↑	Ministry of Education of the Peo-ple's Republic of China	GO	CHN	AS	44,199 ↑	12.94 ↑	.86 →	34.88 ↓	.65 ↓	10.07 ↓	69.31 ↓	6.78 ↓
15 ↓	5 →	4 →	Johns Hopkins Univ.	HE	USA	NA	43,289 ↑	30.93 ↑	2.1 ↑	73.79 ↓	.57 →	24.2 ↓	56.03 ↓	11.65 ↓
16 ↓	6 →	5 →	Univ. of California, Los AngeIes	HE	USA	NA	42,932 ↑	29.97 ↑	2.09 →	71.88 ↓	.44 →	24.78 ↓	55.96 ↓	12.08 ↓
17 →	7 →	6 →	Veterans Affairs Medical Centers	HE	USA	NA	41,538 ↑	16.94 ↑	1.94 ↑	76.14 ↓	.73 →	22.99 ↓	41.93 ↓	7.74 ↓
18 ↓	5 ↓	4 ↓	Zriejian Univ.	HE	CHN	AS	41,359 ↑	16.99 ↑	.8 ↑	30.69 ↑	.6 ↓	9.1 ↑	78.14 ↓	6.44 ↑
19 ↑	5 ↑	2 →	Intitut National de la Sante et de la Recherche Medicale	HE	FRA	WE	40,866 ↑	41.58 ↑	1.71 ↑	69.75 ↑	.7 →	20.94 ↑	47.01 ↓	8.94 ↑
20 ↓	8 →	7 →	Univ. of Washington	HE	USA	NA	40,693 ↑	27.25 ↑	2.09 ↑	72.49 ↑	.45 ↑	24.82 ↓	54.33 ↓	11.38 ↓

Source.—SCIMago 2013 (http://www.scimagoir.com/pdf/SIR%202012.pdf).

Note.—SCIMago brings together SCOPUS Indexed paper results from universities and research institutes (e.g., Academy of Sciences). WR = world ranking; RR = regional ranking; CR = country ranking; GO = government; HE = higher education; HL = health; O = output; IC = international collaboration; NI = normalized impact; Q1 = high-quality publications; Spec. = specialization index; Exc = excellence rate; Lead = scientific leadership; EwL = excellence with leadership. See explanations about methodology at http://www.scimagoir.com/pdf/SCImago%20Institutions%20Rankings%20IBER%20en.pdf.

the pressure on their FTE positions to increase performance in order to maintain their jobs.

The ratios of university-produced SCI/SSCI papers per HC and FTE suggest that Russia was losing its productivity per HC in 2010 (down to 0.27 from 0.33 in 2000). However, Russian scientists were still more productive in comparison with scientists in Brazil, China, Germany, and Japan (table 4). Chinese scientists initially lagged behind Japanese FTE scholars (0.15 papers per Chinese scholar vs. 0.25 per Japanese scholar in 2000) but moved rapidly up in FTE productivity in 2010 (0.42 compared with 0.33).

Part of the increasing productivity in China can be explained by better global connectivity. Research on Chinese university personnel and knowledge diasporas suggests that the linkages of Chinese researchers working, studying, or traveling abroad have created an influential network in support of the Chinese positions in global knowledge production.[4] Chinese scientists have been increasingly benefiting from international coauthorship. Table 4 shows that the coauthorship of Chinese scholars with US scholars grew from 2,561 papers in 2000 to 14,685 in 2010 (almost sixfold), and the proportion of Chinese-American coauthored papers in the total Chinese SCI/SSCI production increased from 8.6 to 10.7 percent, and 9.6 percent in the cumulative volume). We note too that Chinese scholars collaborated more with G7 members than with BRICS. While the same pattern is observed among other BRICS members (i.e., stronger linkages to G7 R&D producers), the BRICS scholars increasingly collaborated among themselves too.

While Russian scientists slowed down coauthorship in SCI/SSCI journals in 2010, their collaborative engagements have been increasing. Chinese-Russian coauthored SCI/SSCI papers grew from 179 in 2000 to 528 in 2010, with a cumulative volume reaching 3,650 over that decade. However, if we keep in mind different personnel numbers, the 11-times larger university R&D personnel in China undoubtedly contributes to the impression that China's rate of collaborations has been increasing faster than Russia's (fourfold vs. twofold on average, respectively). In comparison with China's more dynamic linkages with Western countries, the pace of Russian coauthorship with Germany and the United States looks sluggish over the last decade.

To achieve the Kremlin's aspiration to move at least five national research universities into the world top 100 by 2020, Russian scientists would certainly have to change their strategy from "catching-up" to "accelerative development." Russian universities procrastinated on critical reforms and overlooked (or looked with fear at) the introduction of global selectivity and productivity schemes in the early 2000s. In fact, most of the Russian publications remained with the Russian Academy of Sciences, which held third place globally for SCOPUS-indexed papers in the SCIMago Lab's ranking of research institu-

[4] Welch and Zhen (2008); Yang (2009); Cai (2011); Yang and Welch (2012).

tions as of 2012 (table 5; see also table 1 for Russian universities' proportion of 50–55 percent of the total production of SCI/SSCI papers, in comparison with Chinese universities: 79.5–89 percent between 2000 and 2010). SCI-Mago's data are also telling: while Russia had only 33 institutions mentioned among the world's 2,392 SCOPUS-indexed performers, China had 360 such institutions. The Chinese Academy of Sciences held second place and was also followed in the top 20 by the 985 Project universities, including Tsinghua (eleventh) and Zhejiang (eighteenth), as well as the Ministry of Education (fourteenth). Meanwhile, the closest Russian contenders, Moscow State University and St. Petersburg University, lagged behind in 106th place and 600th place, respectively.

Recent discussions within the Russian government about the number of the global pyramid-climbing universities and the rate of their publications (e.g., 3,000 SCI papers per university; Karpova 2013) reveal that the norms and performance targets have been largely politicized and still require a lot of fine-tuning to measure up to other contenders in the global race, including their R&D personnel capacities, remuneration schemes, and productivity norms. Table 6 shows that national top performers in both BRICS and G7 members have significantly accelerated their rate of production over the last decade. Moreover, universities in Brazil and China have been targeting SCI/SSCI production levels higher than 5,000 papers per year to catch up with producers in Canada and the USA. SCI/SSCI papers are not the only indicator to gain prominence in the rankings, but they may be viewed by many universities as a more attainable target than Nobel Prizes and Field medals. However, the latter (as well as the "high citation" indicators) have become increasingly important as universities move up the ladder and approach the pinnacle of the global pyramid. For example, compare the differences in correlations between the rise in the number of papers and university positions below 100, and the increasing difficulty in approaching the summit among the top 100s, despite a growth in publications.

As the national and institutional positions in world university rankings depend on the quantity and quality of peer-reviewed publications in internationally recognized journals, the production environments require more attention. In terms of catch-up strategies, the emerging national movers and shakers in Russia placed a lot of hope in the new generation of scientists, educated after the USSR's collapse, who speak English and are eager to be part of the global community. Meanwhile, a growing number of their counterparts in China, most holding Western degrees, have been moving their institutions to the next level: that is, coaching their peers back at home in English proficiency and Western publication standards, sorting university and journal brands, promoting Chinese postdocs to faculty positions in world-class universities, launching SCI English-language journals at home and increasing Chinese representation on the editorial boards of the globally rep-

TABLE 6

NATIONAL TOP PRODUCERS IN THE ARWU RANKINGS AND THEIR SCI/SSCI PRODUCTION (2000–2010)

	ARWU Ranking		Total No. of Articles			National Total (NT)	% of the NT	Total No. of Articles (SSc)			NT	% of NT, SSc	% of SSc Articles in Total No. of Articles		
	03	10	00	10	00–10	00–10	00–10	00	10	00–10	00–10	00–10	00	10	00–10
Brazil:															
Univ. of Sao Paulo	152–200	101–50	2,221	6,513	45,904	213,340	21.52	126	670	3,197	13,461	23.75	5.67	10.29	6.96
State Univ. of Campinas	351–400	201–300	427	731	4,912	213,340	2.30	16	48	183	13,461	1.36	3.75	6.57	3.73
Federal Univ. of Minas Gerais	NA	301–400	114	77	1,205	213,340	.56	2	10	42	13,461	.31	1.75	12.99	3.49
Russia:															
Moscow State Univ.	102–51	74	2,212	2,959	30,912	280,403	11.02	30	45	396	5,405	7.33	1.36	1.52	1.28
St. Petersburg State Univ.	401–50	301–400	857	970	10,302	280,403	3.67	10	14	180	5,405	3.33	1.17	1.44	1.75
China:															
Peking Univ.	251–300	151–200	1,192	4,327	28,795	831,517	3.46	16	294	1,241	22,900	5.42	1.34	6.79	4.31
Tsinghua Univ.	201–50	151–200	44	4,197	13,243	831,517	1.59	0	189	463	22,900	2.02	.00	4.50	3.50
Fudan Univ.	301–50	201–300	716	3,191	19,900	831,517	2.39	7	134	436	22,900	1.90	.98	4.20	2.19
South Africa:															
Univ. of Cape Town	251–300	201–300	601	1,359	9,770	54,523	17.92	74	330	1,734	8,904	19.47	12.31	24.28	17.75
Univ. of the Witwatersrand	451–500	301–400	553	1,004	7,564	54,523	13.87	75	270	1,478	8,904	16.60	13.56	26.89	19.54
Univ. of KwaZulu-Natal	451–500	401–500	18	834	4,299	54,523	7.88	0	172	708	8,904	7.95	.00	20.62	16.47
Canada:															
Univ. of Toronto	23	27	4,229	7,445	61,062	452,082	13.51	722	1,664	11,264	68,268	16.50	17.07	22.35	18.45
Univ. of British Columbia	35	36	2,457	5,012	39,122	452,082	8.65	335	1,069	6,912	68,268	10.12	13.63	21.33	17.67
McGill Univ.	79	61	2,605	4,052	35,296	452,082	7.81	320	792	5,086	68,268	7.45	12.28	19.55	14.41
Germany:															
Univ. of Munich	48	52	4,061	6,110	52,798	797,490	6.62	198	498	3,262	53,791	6.06	4.88	8.15	6.18
Technical Univ. Munich	60	56	1,685	2,973	23,581	797,490	2.96	29	144	682	53,791	1.27	1.72	4.84	2.89
Univ. of Heidelberg	58	63	1,887	3,101	25,774	797,490	3.23	90	281	1,670	53,791	3.10	4.77	9.06	6.48
US:															
Harvard Univ.	1	1	7,413	11,653	100,069	3,050,652	3.28	1,370	2,451	18,451	501,539	3.68	18.48	21.03	18.44
Univ. of California, Berkeley	4	2	4,026	5,800	51,305	3,050,652	1.68	540	949	7,196	501,539	1.43	13.41	16.36	14.03
Stanford Univ.	2	3	3,980	5,833	51,179	3,050,652	1.68	664	1,028	7,997	501,539	1.59	16.68	17.62	15.63

SOURCE.—ARWU 2013; Thomson Reuters, "Web of Science: Core Collection," accessed via http://apps.webofknowledge.com.

NOTE.—In the "ARWU Ranking" column, the higher the ranking, the lower the number, and vice versa. SSc = social sciences.

utable journals abroad, and building diaspora knowledge networks. To nurture a more "competitive attitude," some of the new-generation scholars began to defy the custom of *guanxi* (i.e., wining and dining to please important decision makers and influential networkers), choosing to devote their time and full focus to research and publications. Enhancing research integrity (e.g., eradicating plagiarism, promoting fair recognition in coauthorship) emerged as a key goal. Empowered by the growth of R&D expenditures per individual researcher (table A3), Chinese academics began to work toward improving their positions at the summit of the global pyramid, such as by reducing the gap among the "highly cited" institutions (see table A7 for two leading universities).

Discussion and Concluding Remarks

Competitive positioning is increasingly becoming an inseparable part of national and institutional strategies for scientific alliances, networks, and collaborative projects in the new economies. Given the intricate layouts of resource distribution locally and globally, scientists in these economies may be in either powerful or vulnerable positions to make choices and attain benefits. Power and vulnerability are both shaped by interdependencies between hierarchies (vertical escalation) and networks (lateral expansion) that evolve through national policies, institutional strategies, and individual behaviors. Governments create selective funding programs and encourage collaborations with competitive national "Ivy Leagues" elsewhere, while benchmarking local scientific performance through global metrics. The positional goods seem to be serving the purposes of governmental nationalism, postcolonial resistance, and global science in equal measure (Marginson et al. 2010; King 2011). While aiming to level inequalities, the application of global metrics appears to reinstate universal scientific standards and encourage improved local accountability. The positioning appeals to reformers in the global South, as well as in the global North: for the former, it allows for the repudiation of a dwarfing legacy by reversing brain drain and/or recruiting new talent; for the latter, it legitimizes their global hegemony and encourages priority funding and political support for national heavyweights. As status anxiety grows among universities in the South and the North, governments make efforts to further enhance the advantages of those who emerged as "the first movers" and hence escalate resource asymmetries locally and globally (Merton 1988; Altbach and Balan 2007; Marginson et al. 2010).

Befitting its open-door policy, the Chinese government confronted the low standing of its national universities and took radical steps to elevate its global position through selective funding. Chinese universities responded with smart strategies to incentivize global networking and SCI publications. Somewhat halfheartedly, their Russian counterparts began to reshape their patriotic stand in order to catch up with the global standards. The younger generations' perceptions of the post-Soviet reality are being restructured, as China demonstrates how weighing national growth on global scales can recalibrate the national spirit and boost capacity for competitive success. Branding strategies help generate an image that is attractive to resource providers, and "cumulative advantage" is seen as securing exponential benefits at individual, institutional, and national levels, at least for the major players in higher education. In particular, "high producers" are often empowered to demand higher quality academic environments, including improved access to global networks, freedom of expression, and enhanced autonomy (Yang and Welch 2012). In the long run, new generations of academic scientists are most likely to benefit from their institutions' efforts to legitimize performance frameworks favoring scientific merit.

Within the global geometry of ubiquitous rankings, competitiveness indicators, and sensationalist media, national and institutional R&D performance gains broader appeal when it is attuned to internationally verifiable measures that allow local politicians to claim progress and leadership, in order to strengthen their influence locally and expand it nationally or globally. The global engagement of China and Russia, and especially the quest to gain entry and favorable position in elite global clubs, certainly offers opportunities for local economies to attract foreign direct investments, improve trade balances, retain talent, and improve the sense of national self-worth.

At the same time, concerns about global hierarchies are growing among scholars and policy makers who are witnessing closed and stifling environments and are immersed in quarrels about the ranks, impact factors, and career benefits associated with selective publication maneuvers. The pursuit of competitive advantage for the sake of pride (either national, institutional, or individual) sets in motion a self-destructive pathway. The foundation of pride has proven to be historically fleeting and deceptive for both Russia and China. For example, driven by the Cold War and competition for military prowess, Soviet science contributed to building a colossus on feet of clay while channeling public expenditures to the development of lethal weapons rather than to improvements in the quality of life. The pride of the Soviet people turned out to be misguided, and Russia became a dwarf in global science after the Soviet Union's collapse. These days, Russia appears to be leaning on the shoulders of the Chinese giant currently dominating the world economy, in the same way that China leaned on the Soviet Union 60 years ago. The reciprocal learning and borrowing of modernization policies may make sense.

However, the two countries' enduring predilection for science with military-industrial or ideological purposes contributes to their continued failure to take note of the major lesson from the Soviet period: that is, that over-inflated national pride in technology and science and their prioritization over social sciences and humanities can have negative consequences for societal development, particularly when notions of human dignity, critical thinking, and diversity of cultures, languages, or beliefs are ignored or contorted. Social sciences and humanities could have played a crucial role in preventing the repressive practices and legacy of the Soviet Union. Given their ideological constraints, however, Soviet governments and universities muffled academic dissenters, bred double-speak and self-censorship, and paralyzed critical analysis and empowerment of new generations that could have worked to establish good governance and constructive international relations. While Chinese universities have been working diligently to distance themselves as much as possible from the Soviet traditions, the Russian higher education system is increasingly pushed by retrograde forces to reembrace the authoritarian legacy. The current dwarfing of Russian social sciences and humanities in the global leagues (as signified by data in tables 1 and 6) is expressed in ways that range from increased governmental control over R&D expenditures to enhanced governmental oversight of the international ties established at local universities.

According to some Chinese scientists who contributed to this study, finding stability "on the shoulders of giants" increasingly requires communications and creative talent that facilitates mutual exchange and understanding across cultures. However, many of the collaborators in the "new open door environment" also recognize that working together in social sciences and humanities can be significantly more difficult than in the science and technology fields: the former are predisposed to divides—if not clashes—in values, as well as to cultural and political perspectives that often impede collaborations. Ensuring that local social science and humanities translate globally, and vice versa, depends on a number of sociocultural and political preconditions, including a mutual understanding of languages, histories, cultures, conceptual perspectives, growth aspirations, and so on. National and institutional engagement in discourses about global social science and humanities depends heavily on the capacity of individual scientists to handle cross-cultural, bilingual, or multilingual communication and learning. Individual capacities may not emerge or grow in the absence of institutional and national incentives for contributions to the global commons. The social responsibilities agenda in these commons can easily remain on the periphery of scholarly planning when national and institutional policies reward reputable citation indexes, but offer insignificant recognition of academic contributions to reducing inequalities, improving livelihoods and environments, as well as instituting better governance and fairer legal frameworks.

Socially relevant research questions about what is measured in global science should not be excluded from ranking systems and global performance indicators. Indeed, the greater societal goals can be shaped through constructivist learning that reflects on what is reputable and what needs to be rewarded more in academic science. For example, would differentiated score attributions for globally recognized and credible humanitarian awards attained by faculty and alumni (e.g., Nobel Peace Prize and others) urge universities and scholars to give higher priority to social agendas and collaborations? What types of criteria refinement in prestigious global tables can reduce mindless number games and enhance discussions about linkages between global science and local development? What types of criteria could prevent closures in times of global openings, especially when privileges derived through globalism (e.g., increased productivity and influence in global networks, growing prestige, and funding) push disadvantaged scholars (e.g., those lacking foreign-language skills or competitive funding) to protect their entrenched positions in the face of change? What can create an inclusive and mutually empowering collaborative space in global science? These questions gain importance, as asymmetries and disadvantages at the local level threaten to distort healthy networking, collaboration, and upkeep at the international level.

In closing, Merton's "giant-dwarf" aphorism encourages a rethinking of individual roles and responsibilities in advancing institutional and national positions in global science, and vice versa. Positional goods do increasingly matter, and a multistakeholder redistribution of resources may be required to reduce center-periphery tensions. Which countries and which university units have the capacity to claim positional goods that will help them evolve into giants, rather than dwarfs, is a matter of political deliberations, economic opportunities, and individual aspirations. More often than not, global players confront "the self-fulfilling prophecy that inequalities will emerge sooner or later." Whereas some benefit more and others succeed less, the ultimate concern should be about the extent and value of scientific contribution to the global public good, rather than about metrics alone. In Merton's words, the collaborative ideal should transcend asymmetries and assume the search for mutual advantage: "the double-edged character of the giant-and-dwarf figure . . . can be used just as effectively to extol the dwarfs who are raised high on the giants' shoulders as to extol the giants without whom there would be no eminence from which the little men could see far and wide" (1965, 43).

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